PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-219375
(43)Date of publication of application : 18.08.1998

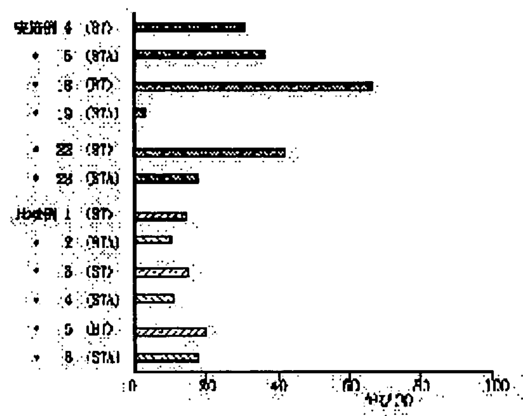
(51)Int.CI. C22C 14/00
A61C 8/00
A61L 27/00
C22C 30/00
C22F 1/18
// C22F 1/00
C22F 1/00
C22F 1/00

(21)Application number : 09-020588
(22)Date of filing : 03.02.1997

(71)Applicant : DAIDO STEEL CO LTD
(72)Inventor : ARAYA MITSUO
MORINAGA MASAHIKO
KURODA DAISUKE

(54) TITANIUM ALLOY AND HARD TISSULAR SUBSTITUTIVE MATERIAL USING SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a new titanium alloy having strength particularly suitable for an organic hard tissular substitutive material for the such as bone, a part of the bone, prostheses for the bone, an artificial joint, a dental root, and an implant, and also having high elongation and low elastic modulus and also to provide a hard tissular substitutive material using this titanium alloy.
SOLUTION: The titanium alloy has a composition consisting of, by weight, 20-60%, in total, of Nb and Ta and the balance Ti with inevitable impurities. It is desirable to regulate Nb content and Ta content to >15-50% and >6-20%, respectively. One or ≥2 kinds among ≤10% Mo, ≤5% Zr, and ≤5% Sn are further added to the above titanium alloy. The hard tissular substituting material is obtained by subjecting these titanium alloys to solution heat treatment or further to aging treatment.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平10－219375

(43)公開日　平成10年(1998)8月18日

(51)Int.Cl.[6]	識別記号	ＦＩ	
Ｃ２２Ｃ　14/00		Ｃ２２Ｃ　14/00	Ｚ
Ａ６１Ｃ　8/00		Ａ６１Ｃ　8/00	Ｚ
Ａ６１Ｌ　27/00		Ａ６１Ｌ　27/00	Ｌ
Ｃ２２Ｃ　30/00		Ｃ２２Ｃ　30/00	
Ｃ２２Ｆ　1/18		Ｃ２２Ｆ　1/18	Ｈ

審査請求　未請求　請求項の数６　ＯＬ　（全　６　頁）　最終頁に続く

(21)出願番号　特願平9－20588

(22)出願日　平成９年(1997)２月３日

特許法第30条第１項適用申請有り　平成８年９月30日　社団法人日本鉄鋼協会開催の「第132回秋期講演大会」において文書をもって発表

(71)出願人　000003713
大同特殊鋼株式会社
愛知県名古屋市中区錦一丁目11番18号

(72)発明者　新家　光雄
愛知県豊橋市野依台１－24－13

(72)発明者　森永　正彦
愛知県名古屋市中区丸の内二丁目10番28号
グランエステート丸の内1002号室

(72)発明者　黒田　大介
愛知県豊橋市橋良町字東郷20－４　ハイツサーティーワン２－Ａ

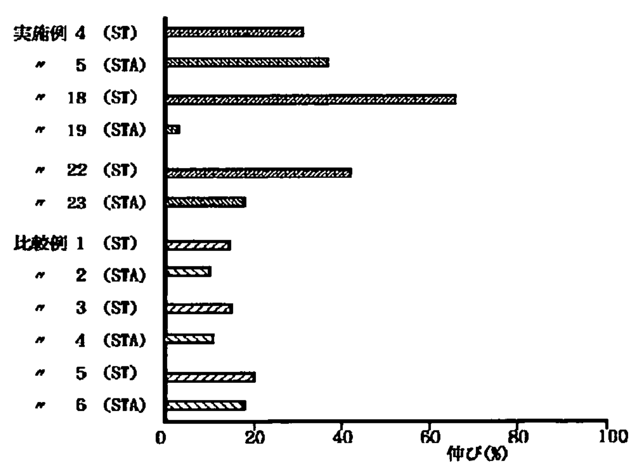
(74)代理人　弁理士　鈴木　学

(54)【発明の名称】　チタン合金とこれを用いた硬質組織代替材

(57)【要約】

【課題】　骨又はその一部、或いはその補助材、人工関節、歯根、又はインプラント材等の生体の硬質組織代替材に特に適した強度と、高い伸び、及び低い弾性率を有する新たなチタン合金と、これを用いた硬質組織代替材を提供する。

【解決手段】　Ｎｂ及びＴａを合計で２０wt%～６０wt%含み残部がＴｉと不可避的不純物からなるチタン合金。上記Ｎｂの含有量は１５wt%超～５０wt%以下の範囲が、また、上記Ｔａは６wt%超～２０wt%以下の範囲が望ましい。これらのチタン合金に、更に１０wt%以下のＭｏ、５wt%以下のＺｒ、又は５wt%以下のＳｎの一種又は二種以上を添加したチタン合金も含まれる。更に、これらのチタン合金を溶体化処理し、或いはその後に時効処理した硬質組織代替材も含まれる。



【特許請求の範囲】

【請求項１】Ｎｂ及びＴａを合計で２０wt%～６０wt%含み、残部がＴｉと不可避的不純物からなることを特徴とするチタン合金。

【請求項２】前記Ｎｂの含有量が１５wt%超～５０wt%以下であることを特徴とする請求項１に記載のチタン合金。

【請求項３】前記Ｔａの含有量が６wt%超～２０wt%以下であることを特徴とする請求項１又は２に記載のチタン合金。

【請求項４】前記チタン合金に、更に１０wt%以下のＭｏ、５wt%以下のＺｒ、又は、５wt%以下のＳｎの一種又は二種以上を添加したことを特徴とする請求項１乃至３に記載のチタン合金。

【請求項５】前記チタン合金に溶体化処理を施し、このチタン合金の結晶粒を再結晶させたことを特徴とする請求項１乃至４に記載の硬質組織代替材。

【請求項６】前記溶体化処理の後に、前記チタン合金に時効処理を施したことを特徴とする請求項５に記載の硬質組織代替材。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、新規なチタン(Ｔｉ)合金に関し、特に生体の人工骨材又はその一部、或いはそれらの補助材のような硬質組織代替材に適したチタン合金と、このチタン合金を用いた硬質組織代替材に関する。

【０００２】

【従来の技術】一般に、歯科用の人工歯根や医療用の人工骨材には、Ｔｉ-6wt%Ａｌ-4wt%Ｖに代表されるチタン合金が適用又は検討されている。これは、チタンが他の金属に比べ、生体内において高い適応性を有することによる。しかし、種々の研究によると、上記チタン合金のうちＶ(ﾊﾞﾅｼﾞｳﾑ)は、生体の細胞に対し、毒性を有することが指摘されている。このため上記Ｖに替えてＮｂやＦｅを添加したＴｉ-6wt%Ａｌ-7wt%Ｎｂや、Ｔｉ-5wt%Ａｌ-2.5wt%Ｆｅ等の所謂$\alpha+\beta$型のチタン合金が提案されている。しかし乍ら、これらの合金中のＡｌ(ｱﾙﾐﾆｳﾑ)は、ある種の痴呆症を招くという指摘もなされている。

【０００３】そこで、上記毒性やアレルギー性の指摘がない金属元素を用い、$\alpha+\beta$型チタン合金よりも高い伸びと、優れた冷間加工性を有すると共に、弾性率を低くして生体内の硬質組織に近付けるべくβ型チタン合金が提案されるようになった。このβ型チタン合金には、例えばＴｉ-１３wt%Ｎｂ-１３wt%Ｚｒ、Ｔｉ-１６wt%Ｎｂ-１０wt%Ｈｆ、Ｔｉ-１５wt%Ｍｏ、Ｔｉ-１５wt%Ｍｏ-5wt%Ｚｒ-3wt%Ａｌ、Ｔｉ-１２wt%Ｍｏ-6wt%Ｚｒ-2wt%Ｆｅ、Ｔｉ-１５wt%Ｍｏ-2.8wt%Ｎｂ-0.2wt%Ｓｉ-0.２６wt%Ｏ等が含まれている。しかし乍ら、上記各β型チタン合金のうち、どのような成分組成の合金が人工骨材等のような硬質組織代替材に適しているか、あまり研究されておらず、未だ不明確であった。

【０００４】

【発明が解決すべき課題】本発明は、上記従来の技術に鑑み、生体の硬質組織代替材に特に適し、生体に対し毒性やアレルギーが少なく、適度な強度と高い伸び率、及び低い弾性率を有すると共に、耐食性にも優れた生体の活動にフィットする新たなチタン合金と、このチタン合金を用いた硬質組織代替材を提供することを目的とする。

【０００５】

【課題を解決するための手段】本発明は、上記課題を解決するため、β型チタン合金について発明者らが鋭意研究した結果、チタンに対しＮｂ(ﾆｵﾌﾞ)と共にＴａ(ﾀﾝﾀﾙ)を併せて所定量ずつ添加することに着目することにより得られたものである。即ち、本発明のチタン合金は、Ｎｂ及びＴａを合計で２０wt%～６０wt%含み、残部がＴｉと不可避的不純物からなることを特徴とする。係る組成の合金にすると、上記課題を解決することが可能となる。尚、上記ＮｂとＴａを合計する範囲の上限は、５０wt%とするのが望ましい。このチタン合金のうち、Ｎｂの含有量は、１５wt%超～５０wt%以下の範囲内にあることが望ましい。Ｎｂが１５wt%以下では、金属組織中にα相が析出し、一方、Ｎｂが５０wt%を超過すると、伸びが不足し始めるためであり、Ｎｂのより望ましい上限は４５wt%である。

【０００６】また、前記Ｔａの含有量は、６wt%超～２０wt%以下の範囲内にあることが望ましい。Ｔａが6wt%以下になると伸びが不足し始め、一方、Ｔａが２０wt%を超過すると、合金自体の融点が上がり過ぎるためであり、Ｔａのより望ましい上限は１５wt%である。更に、上記の各チタン合金に対し、更に、１０wt%以下のＭｏ(ﾓﾘﾌﾞﾃﾞﾝ)、5wt%以下のＺｒ(ｼﾞﾙｺﾆｳﾑ)、又は、5wt%以下のＳｎ(錫)の一種又は二種以上を添加したものも含まれる。係る各元素を添加することにより、一層安定した特性を有するチタン合金を得ることが可能となる。

【０００７】また、本発明には、上記チタン合金を用い、これらに溶体化処理を施して、その結晶粒を再結晶させたことを特徴とする硬質組織代替材、及びその溶体化処理の後に更に時効処理を施した硬質組織代替材も含まれる。上記溶体化処理及び／又は時効処理を施すことにより、β相における結晶粒が微細化され、強度を適正に高め、且つ伸びと弾性率を適正化することができる。係る硬質組織代替材によれば、骨、又は歯根として、或いは、義歯、義肢、又は義足等の構成部材として用いることで、生体の活動に馴染んだ特性及び効果を得ることができ、医療技術の向上に寄与することが可能となる。

【0008】

【発明の実施の形態】以下に本発明の実施に好適な形態を実施例と共に説明する。Ｔｉをベースとし、Ｔｉと共に生体への適応性の高いＮｂ及びＴａを組合せ、更にＭｏ、Ｚｒ、又はＳｎを付随的に添加した種々の成分組成を有するチタン合金をそれぞれ溶解した。これらの合金を鋳型中に鋳込んで一定サイズのインゴットをそれぞれ得た。次いで、係る各インゴットに所定の冷間加工を施した後、それらの各加工材から所要数の薄板を切り出した。次に、これらの薄板にそれぞれ所定の溶体化処理及び／又は時効処理を施した(図１参照)後、所要形状の試験片に仕上げて引張り試験等を行った。また、比較例として、前記従来の技術に示した$\alpha+\beta$型及びβ型のチタン合金を、上記図１と同じ溶解から熱処理までのプロセスを経させて試験片とし、これらについても同じ引張り試験等を行った。

【0009】

【実施例】以下において具体的な実施例を挙げて、比較例と共に説明する。Ｔｉに生体への適応性の高いＮｂ及びＴａを種々組合せ、更にＭｏ、Ｚｒ、又はＳｎを付随的に添加した表１に示す各成分組成のチタン合金を溶解した。一方、比較例として、表１に示すＴｉ-6wt%Ａｌ-4wt%Ｖ等($\alpha+\beta$型)と、Ｔｉ-１３wt%Ｎｂ-１３wt%Ｚｒ等(β型)を溶解した。

【0010】

【表１】

【0011】次いで、これらの各チタン合金を所定の鋳型中において鋳造し、それぞれについて４５ｇのボタンインゴットを得た。係る各ボタンインゴットに対し冷間圧延(圧下率７５%)を行って、各合金組織内の結晶粒を微細化させた延べ板を得た。次に、これらチタン合金の各延べ板から、薄板を各合金についてそれぞれ１０片ずつ切り出した。更に、各薄板に対し、表１に示す条件の溶体化処理(ＳＴ)を行って、それらの組織内に１０～５０μm程度の結晶粒径に再結晶させると共に、そのうちの５片ずつについては、その後、引き続いて時効処理(ＳＴＡ)を施した(図１参照)。

【0012】尚、前記表１中の時効処理(Aging)の処理時間を３時間以上としたのは、図２のグラフに示すように、３時間未満では硬度が不安定であるのに対し、これを越えると安定した硬度になるためである。上記各薄板は、図３に示す引張り試験片１に仕上げ加工される。これらの各試験１片についてＪＩＳ；Ｚ２２４１に従って引張り試験を行うことにより、引張り強さ(σ_B／ＭＰａ)、０.２%耐力($\sigma_{0.2}$／ＭＰａ)、伸び率(%)、及び、弾性率(ＧＰａ)をそれぞれ測定した。それらの測定結果(平均値)を表２に示す。

【0013】

【表２】

【0014】前記表２の結果を分かり易くするため、実施例No.４、５、１８、１９、２２、２３と比較例No.１～６の各引張り強さ、伸び率、及び弾性率をそれぞれ図４乃至図６にグラフとして示した。尚、０．２%耐力のグラフは、図４の引張り強さと同様の傾向であったため、省略した。これらの結果から、各実施例の溶体化処理のみを施したＳＴ材(4,18,22)は、何れも伸び率が３０%以上と各比較例よりも高くなり(図５参照)、また、引張り強さと弾性率は比較例よりも低い値を示した(図４，６参照)。尚、比較例のように、引張り強さと弾性率が高いと、それらが生体に適用された部位に接する骨等の表面を磨耗させ、傷付け易くなる恐れがある。特に骨の弾性率は、約３０ＧＰａであるため、これに近い程、生体への適応性が高くなる。これらの結果から、各実施例のチタン合金のＳＴ材は、優れた伸び特性を有すると共に、強度や弾性率は比較例よりも低く、生体の硬質組織に近似するので、例えば、骨折部の残存組織内に挿入されると、その変形に対し一体となって追従して変化し、骨の一部となって長く使用することが可能になる。

【0015】一方、各実施例の時効処理も施したＳＴＡ材(5,19,23)は、引張り強さが同じ組成のＳＴ材より高いが、各比較例と同等か又はこれらよりやや低い(図４参照)。また、伸び率は実施例５を除き同じ組成のＳＴ材より低下するが、比較例と同等(１０%超)以上のものも認められる(図５参照)。更に、弾性率は実施例１９を除き比較例よりも低い値を示す(図６参照)。これらの結果から、各実施例のチタン合金のＳＴＡ材は、上記ＳＴ材とは別の比較的硬い硬質組織に対し、適応性が高いものと思われる。これらの結果から、本発明の前記各チタン合金は、溶体化処理及び／又は時効処理を施すことで、生体内における各種の硬質組織に馴染み易い種々の特性が得られることが理解される。尚、前記溶体化処理は、微細な再結晶粒を得るため、８００～１０００℃に加熱して３０～６０分程度保持することが望ましい。また、時効処理は、前記の強度や硬度を得るため、４００～５００℃に加熱して少なくとも２時間以上保持することが望ましく、最長では２４時間保持する場合も含まれる。

【0016】本発明のチタン合金及び硬質組織代替材は、前述した他に、インプラント材、人工関節、又は歯列矯正材等の種々の硬質組織用の代替材、又はその一部の補助材として使用することもできる。また、本発明のチタン合金は、以上のような生体用に限らず、その優れた伸びと適度な強度、低い弾性率、及び優れた耐食性という特性により、医療用以外の各種分野、例えば機械器具材料、福祉器具材料、民生品材料等に適用することも可能である。

【0017】

【発明の効果】以上において説明した本発明のチタン合金によれば、適度な強度と高い伸び及び低い弾性率を得ることができる。また、このチタン合金を用いた硬質組織代替材は、生体の硬質組織に適応した優れた特性を有

し、且つ毒性やアレルギーも少なく長期に渉り生体に馴染み易い材料を提供することが可能となる。

【図面の簡単な説明】

【図1】本発明の硬質組織代替材を得るプロセスを示す概略の流れ図である。

【図2】本発明のチタン合金の時効処理における硬度と処理時間の関係を示すグラフである。

【図3】（A）と（B）は本発明のチタン合金等を用いた引張り試験片の正面図と側面図である。

【図4】実施例と比較例の引張り強さを示すグラフである。

【図5】実施例と比較例の伸び率を示すグラフである。

【図6】実施例と比較例の弾性率を示すグラフである。

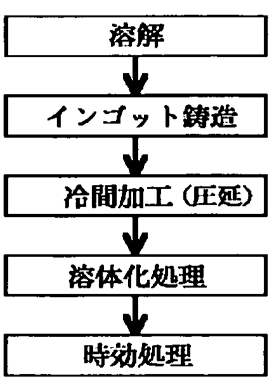
【表1】

	No	合金組成　(wt%)	熱処理
実施例	1	Ti－16 Nb－ 7 Ta	STA；844℃×0.5 hr→ 400℃×3 hr
	2	Ti－20 Nb－ 9 Ta	STA；　〃　→　〃
	3	Ti－25 Nb－11 Ta	STA；　〃　→　〃
	4	Ti－29 Nb－13 Ta	ST　；844℃×0.5 hr
	5	Ti－29 Nb－13 Ta	STA；　〃　→ 500℃×3 hr
	6	Ti－34 Nb－20 Ta	STA；　〃　→ 450℃×3 hr
	7	Ti－40 Nb－10 Ta	STA；　〃　→　〃
	8	Ti－45 Nb－ 8 Ta	STA；　〃　→　〃
	9	Ti－50 Nb－ 7 Ta	STA；　〃　→　〃
	10	Ti－16 Nb－13 Ta	STA；　〃　→ 400℃×3 hr
	11	Ti－21 Nb－12 Ta	STA；　〃　→　〃
	12	Ti－24 Nb－14 Ta	STA；　〃　→　〃
	13	Ti－30 Nb－15 Ta	STA；　〃　→ 500℃×3 hr
	14	Ti－37 Nb－10 Ta	STA；　〃　→ 450℃×3 hr
	15	Ti－42 Nb－ 8 Ta	STA；　〃　→　〃
	16	Ti－18 Nb－10 Ta－2 Mo	ST　；844℃×0.5 hr
	17	Ti－18 Nb－10 Ta－2 Mo	STA；　〃　→ 400℃×3 hr
	18	Ti－16 Nb－13 Ta－4 Mo	ST　；844℃×0.5 hr
	19	Ti－16 Nb－13 Ta－4 Mo	STA；　〃　→ 450℃×3 hr
	20	Ti－34 Nb－20 Ta－4.6 Zr	ST　；844℃×0.5 hr
	21	Ti－34 Nb－20 Ta－4.6 Zr	STA；　〃　→ 400℃×3 hr
	22	Ti－29 Nb－13 Ta－4.6 Zr	ST　；844℃×0.5 hr
	23	Ti－29 Nb－13 Ta－4.6 Zr	STA；　〃　→ 450℃×3 hr
	24	Ti－29 Nb－13 Ta－4.6 Sn	ST　；844℃×0.5 hr
	25	Ti－29 Nb－13 Ta－4.6 Sn	STA；　〃　→ 400℃×3 hr
	26	Ti－29 Nb－13 Ta－2 Sn	ST　；844℃×0.5 hr
	27	Ti－29 Nb－13 Ta－2 Sn	STA；　〃　→ 400℃×3 hr
比較例	1	Ti－ 6 Al－ 4 V	ST　；955℃× 1 hr
	2	Ti－ 6 Al－ 4 V	STA；〃℃× 1 hr→480 ℃×4 hr
	3	Ti－ 5 Al－ 2.5 Fe	ST　；〃℃× 1 hr
	4	Ti－ 5 Al－ 2.5 Fe	STA；〃℃× 1 hr→520 ℃×4 hr
	5	Ti－13 Nb－13 Zr	ST　；775℃× 1 hr
	6	Ti－13 Nb－13 Zr	STA；〃℃× 1 hr→425 ℃×4 hr

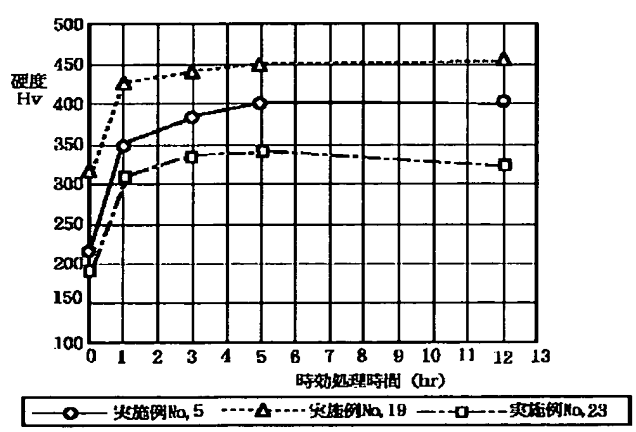
【表2】

	No	引張り強さ（σ_B/MPa）	0.2％耐力（$\sigma_{0.2}$/MPa）	伸び率（％）	弾性率（GPa）
実施例	1	863	840	3	115
	2	803	715	5	73
	3	1210	1190	3	115
	4	560	205	31	63
	5	570	270	36	65
	6	580	410	19	55
	7	560	380	21	53
	8	566	373	23	53
	9	420	415	27	50
	10	840	827	4	104
	11	1185	1147	4	112
	12	1030	968	3	78
	13	430	425	20	53
	14	580	410	17	61
	15	570	410	23	50
	16	776	564	22	80
	17	989	852	15	81
	18	634	550	66	46
	19	1200	1170	3	112
	20	415	410	31	49
	21	419	417	25	50
	22	522	245	42	50
	23	574	330	18	56
	24	527	453	27	60
	25	1035	975	3	65
	26	562	397	23	60
	27	1021	1000	5	67
比較例	1	896	827	15	114
	2	953	822	10	114
	3	901	843	15	115
	4	943	886	11	115
	5	798	599	20	83
	6	994	864	18	81

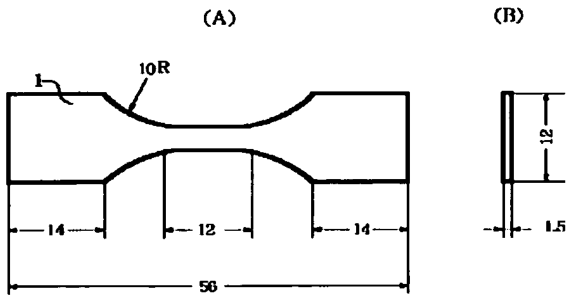
【図1】



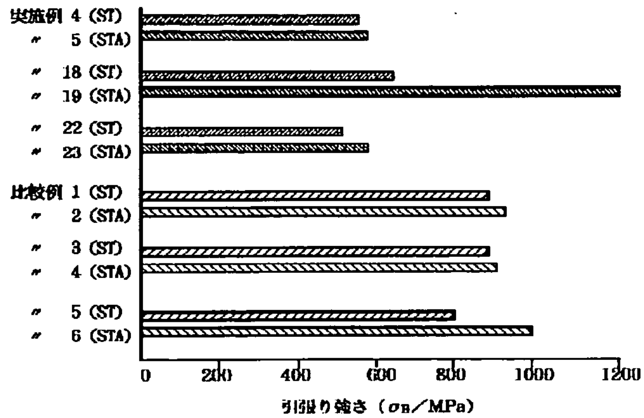
【図2】



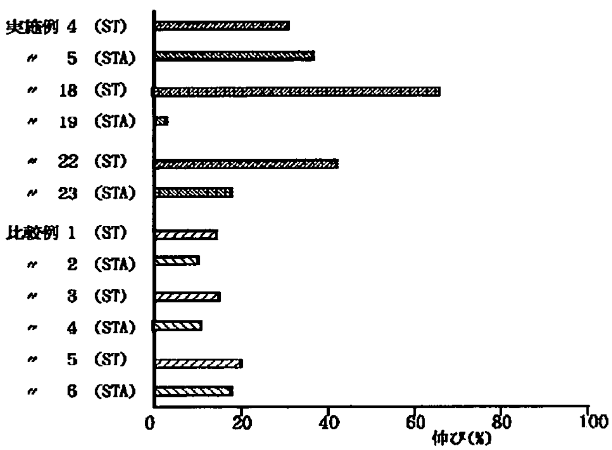
【図3】



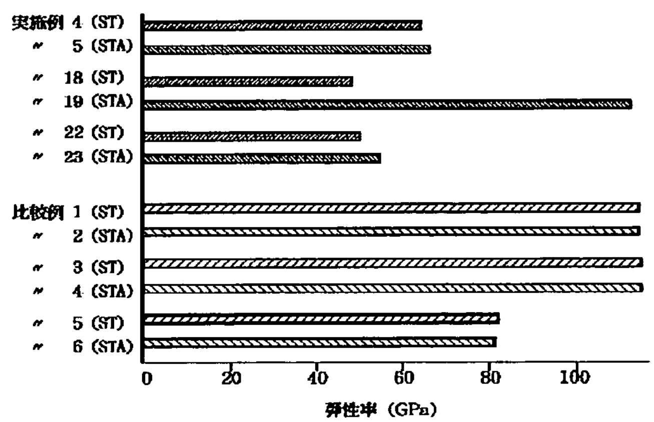
【図4】



【図5】



【図6】



フロントページの続き

(51)Int.Cl.^{6}	識別記号	F I	
// C22F　1/00	630	C22F　1/00	630C
	675		675
	686		686B

* NOTICES *

The Japanese Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The titanium alloy characterized by a 20wt%-60wt% implication and the remainder consisting Nb and Ta of Ti and an unescapable impurity in the sum.
[Claim 2] The titanium alloy according to claim 1 characterized by the content of the above Nb being less than [15wt% ** -50wt%].
[Claim 3] The titanium alloy according to claim 1 or 2 characterized by the content of the aforementioned Ta being less than [6wt% ** -20wt%].
[Claim 4] the aforementioned titanium alloy -- further -- the titanium alloy according to claim 1 to 3 characterized by adding Mo not more than 10wt%, Zr not more than 5wt%, a kind of Sn not more than 5wt%, or two sorts or more
[Claim 5] The hard organization alternate material according to claim 1 to 4 characterized by having performed solution treatment to the aforementioned titanium alloy, and making the crystal grain of this titanium alloy recrystallize.
[Claim 6] The hard organization alternate material according to claim 5 characterized by giving an aging treatment to the aforementioned titanium alloy after the aforementioned solution treatment.

[Translation done.]

* NOTICES *

The Japanese Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the hard organization alternate material using the titanium alloy which was especially suitable for a living body's artificial aggregate or its part or hard organization alternate material like those supplementary material, and this titanium alloy about a new titanium (Ti) alloy.
[0002]
[Description of the Prior Art] Generally, the titanium alloy represented by Ti-6wt%aluminum-4wt%V is applied or examined by the dental implant for dentistries, and the artificial aggregate of medical application. Titanium depends this on having high adaptability in in the living body compared with other metals. However, according to the various researches, it is pointed out among the above-mentioned titanium alloys that V (ha Nasi ** ****) has toxicity to a living body's cell. For this reason, Ti-6wt%aluminum-7wt%Nb which changed to the above-mentioned V and added Nb and Fe, and the so-called alpha+beta type titanium alloys, such as Ti-5wt%aluminum-2.5wt%Fe, are proposed. However, indication that aluminum (aluminum) in **s et al. and these alloys invites a certain kind of ****** is also made.
[0003] Then, while it had the cold-working nature which was excellent with elongation higher than an alpha plus beta titanium alloy using the metallic element without indication of the above-mentioned toxicity or allergy nature, an elastic modulus is made low and a beta titanium alloy came to be proposed that it should bring close to a hard organization in the living body. Ti-13wt%Nb-13wt%Zr, Ti-16wt%Nb-10wt%Hf, Ti-15wt%Mo, Ti-15wt%Mo-5wt%Zr-3wt%aluminum, Ti-12wt%Mo-6wt%Zr-2wt%Fe, Ti-15wt%Mo-2.8wt%Nb-0.2wt%Si-0.26wt%O, etc. are contained in this beta titanium alloy. However, the alloy of what component composition fitted hard organization alternate materials, such as an artificial aggregate, among ** et al. and each above-mentioned beta titanium alloy, or it seldom inquired, but was still indefinite.
[0004]
[Problem(s) to be Solved by the Invention] Especially this invention is suitable for a living body's hard organization alternate material in view of the above-mentioned proior art, and it aims at offering the hard organization alternate material using the new titanium alloy fit for an activity of the living body excellent also in corrosion resistance, and this titanium alloy while there are little toxicity and allergy and they have a moderate intensity, high elongation percentage, and a low elastic modulus to a living body.
[0005]
[Means for Solving the Problem] this invention is obtained by directing one's attention to adding Ta (tantalum) the specified quantity every collectively with Nb (********) to titanium, as a result of artificers' inquiring zealously about a beta titanium alloy, in order to solve the above-mentioned technical probrem. That is, the titanium alloy of this invention is characterized by a 20wt%-60wt% implication and the remainder consisting Nb and Ta of Ti and an unescapable impurity in the sum. If it is made the alloy of the applied composition, it will be enabled to solve the above-mentioned technical probrem. In addition, as for the upper limit of the domain which totals the above Nb and Ta, considering as 50wt% is desirable. As for the content of Nb, it is desirable that it is in less than [15wt% ** -50wt%] within the limits among this titanium alloy. When alpha phase separates [Nb] in a metal texture less than [15wt%] and Nb exceeds 50wt% on the other hand, it is because elongation begins to run short, and the more desirable upper limit of Nb is 45wt%.
[0006] Moreover, as for the content of the aforementioned Ta, it is desirable that it is in less than [6wt% ** -20wt%] within the limits. If Ta becomes less than [6wt%], elongation begins to run short, on the other hand, when Ta exceeds 20wt%, it is for the melting point of the alloy itself] to go up too much, and the more desirable upper limit of Ta is 15wt%. Furthermore, what added Mo not more than 10wt% (****** ** ** ** **), Zr not more than 5wt% (** ** **********), a kind of Sn (tin) not more than 5wt%, or two sorts or more is further contained to each above-mentioned titanium alloy. By adding each element to apply, it is enabled to obtain the titanium alloy which has the property stabilized much more.
[0007] Moreover, using the above-mentioned titanium alloy, solution treatment is performed to these and the hard organization alternate material characterized by making the crystal grain recrystallize and the hard organization alternate material which gave the aging treatment further after the solution treatment are also contained in this invention. By giving the above-mentioned solution treatment and/or an aging treatment, crystal grain in beta phase can be made detailed, and an intensity can be raised proper, and elongation and an elastic modulus can be rationalized. According to the hard organization alternate material to apply, as a bone or a root of tooth, the property and the effect of having got used to a living body's activity can be acquired, and it is enabled to contribute to the enhancement in the iatrotechnique by using as configuration members, such as the prosthesis, an artificial limb, or an artificial leg.
[0008]
[Embodiments of the Invention] The suitable gestalt for operation of this invention is explained with an example below. Ti was used as the base, Nb and Ta with the high adaptability to a living body were combined with Ti, and the titanium alloy which has the various component composition which added Mo, Zr, or Sn subordinately further was melted, respectively. These alloys were cast in mold and the ingot of a fixed size was obtained, respectively. Subsequently, after giving predetermined cold working to each starting ingot, the sheet metal of a required number was cut down from each of those manipulation material. Next, after giving predetermined solution treatment and/or a predetermined aging treatment to these sheet metal, respectively (refer to the drawing 1), it finished to the test piece of a necessary configuration, and the tensile test etc. was performed. Moreover, as an example of a comparison, it was made to pass through the process from the same lysis as the

above-mentioned view 1 to heat treatment, the alpha+beta type shown in the aforementioned proior art and the beta type titanium alloy were used as the test piece, and the same tensile test etc. was performed also about these.

[0009]

[Example] A concrete example is given to below and it explains with the example of a comparison. Various Nbs and Ta with the high adaptability to a living body were combined with Ti, and the titanium alloy of each component composition which shows Mo, Zr, or Sn in Table 1 added subordinately further was melted. On the other hand, Ti-6wt%aluminum-4wt%V shown in Table 1, Ti-13wt%Nb-13wt%Zr (alpha+beta type), etc. were melted as an example of a comparison (beta type).

[0010]

[Table 1]

[0011] Subsequently, each of these titanium alloys were cast in predetermined mold, and the 45g button ingot was obtained about each. The cold rolling (75% of rolling reductions) was performed to each starting button ingot, and the sheet metal which made the crystal grain of each alloy in-house make it detailed was obtained. Next, it cut down ten pieces of sheet metal at a time about each alloy from each sheet metal of these titanium alloys, respectively. Furthermore, while solution treatment (ST) of the conditions shown in Table 1 is performed to each sheet metal and those in-houses were made to recrystallize in the about 10-50-micrometer diameter of crystal grain, about every five pieces of the to shoot, the aging treatment (STA) was given succeedingly after that (refer to the drawing 1).

[0012] In addition, the processing time of the aging treatment (Aging) in the aforementioned table 1 was made into 3 hours or more for becoming the degree of hardness stabilized when this was exceeded to the degree of hardness being unstable in less than 3 hours, as shown in the graph of drawing 2 . The piece 1 of a tensile test shown in drawing 3 finish-machines each above-mentioned sheet metal. By performing a tensile test about one piece of these examinations [each] according to JIS;Z2241, tensile strength (sigmaB/MPa), 0.2% proof stress (sigma0.2/MPa), elongation percentage (%), and the elastic modulus (GPa) were measured, respectively. Those measurement results (average) are shown in Table 2.

[0013]

[Table 2]

[0014] In order to make the result of the aforementioned table 2 intelligible, an example No, 4, 5, 18, 19, 22, 23 and the example No of a comparison, each tensile strength of 1-6, elongation percentage, and the elastic modulus were shown in the drawing 4 or the drawing 6 as a graph, respectively. In addition, since it was the same inclination as the tensile strength of drawing 4 , the graph of 0.2% proof stress was omitted. From these results, as for ST material (4, 18, 22) which performed only solution treatment of each example, elongation percentage became higher [what **] than 30% or more and each example of a comparison (refer to the drawing 5), and tensile strength and the elastic modulus showed the value lower than the example of a comparison (drawing 4 , six references). In addition, like the example of a comparison, when tensile strength and an elastic modulus are high, front faces, such as a bone which touches the site by which they were applied to the living body, are worn, and there is a possibility of becoming easy to damage. The adaptability to a living body becomes high so that it is close to this, since especially bony elastics modulus are about 30 GPas. The thing excellent in ST material of the titanium alloy of each [from these results] example which it will be united to the deformation, will follow, and will change if it is inserted into the relict texture of the fracture section, for example, since an intensity and an elastic modulus are lower than the example of a comparison while it is extended and it has a property, and a living body's hard organization is resembled, and it becomes bony [a part of], and is used for a long time becomes possible.

[0015] Although STA material (5, 19, 23) which, on the other hand, also gave the aging treatment of each example has tensile strength higher than ST material of the same composition, it is equivalent to each example of a comparison, or is a little lower than these (refer to the drawing 4). Moreover, although elongation percentage falls from ST material of the same composition except for an example 5, the thing more than the example of a comparison and an EQC (10% **) also accepts (refer to the drawing 5). Furthermore, an elastic modulus shows a value lower than the example of a comparison except for an example 19 (refer to the drawing 6). From these results, STA material of the titanium alloy of each example is considered to be what has high adaptability to the comparatively hard hard organization other than the above-mentioned ST material. From these results, each aforementioned titanium alloy of this invention is giving solution treatment and/or an aging treatment, and it is understood that the various properties of being easy to get used to various kinds of hard organizations in the living body are acquired. In addition, in order to obtain a detailed recrystallization grain, as for the aforementioned solution treatment, it is desirable to heat at 800-1000 degrees C, and to hold about 30 to 60 minutes. Moreover, in order to obtain an aforementioned intensity and an aforementioned degree of hardness, as for an aging treatment, it is desirable to heat at 400-500 degrees C, and to hold at least 2 hours or more, and when holding for 24 hours, it is contained by the longest.

[0016] It mentioned above, and also the titanium alloy and hard organization alternate material of this invention can also be used as the alternate material for [, such as an implant material an artificial joint, or orthodontics material,] various hard organizations, or supplementary material of the part. Moreover, not only the above objects for living bodies but the titanium alloy of this invention can be applied to various fields other than medical application, for example, a machine instrument material, a welfare instrument material, a public welfare article material, etc. with the outstanding elongation, a moderate intensity, a low elastic modulus, and the property of the outstanding corrosion resistance.

[0017]

[Effect of the Invention] According to the titanium alloy of this invention explained above, a moderate intensity, high elongation, and a low elastic modulus can be obtained. Moreover, the hard organization alternate material using this titanium alloy has the outstanding property which was adapted for a living body's hard organization, and becomes possible [that toxicity and allergy also offer the material which is easy to get used to a **** living body at a long period of time few].

[Translation done.]

* NOTICES *

The Japanese Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the flow chart of an outline showing the process which obtains the hard organization alternate material of this invention.
[Drawing 2] It is the graph which shows the relation between a degree of hardness and the processing time in the aging treatment of the titanium alloy of this invention.
[Drawing 3] (A) and (B) are the front view and the side elevations of the piece of a tensile test which used the titanium alloy of this invention etc.
[Drawing 4] It is the graph which shows the tensile strength of an example and the example of a comparison.
[Drawing 5] It is the graph which shows the elongation percentage of an example and the example of a comparison.
[Drawing 6] It is the graph which shows the elastic modulus of an example and the example of a comparison.
[Table 1]

	No	合金組成 (wt%)	熱処理
実施例	1	Ti－16 Nb－ 7 Ta	STA; 844℃×0.5 hr→ 400℃×3 hr
	2	Ti－20 Nb－ 9 Ta	STA; 〃 → 〃
	3	Ti－25 Nb－11 Ta	STA; 〃 → 〃
	4	Ti－29 Nb－13 Ta	ST ; 844℃×0.5 hr
	5	Ti－29 Nb－13 Ta	STA; 〃 → 500℃×3 hr
	6	Ti－34 Nb－20 Ta	STA; 〃 → 450℃×3 hr
	7	Ti－40 Nb－10 Ta	STA; 〃 → 〃
	8	Ti－45 Nb－ 8 Ta	STA; 〃 → 〃
	9	Ti－50 Nb－ 7 Ta	STA; 〃 → 〃
	10	Ti－16 Nb－13 Ta	STA; 〃 → 400℃×3 hr
	11	Ti－21 Nb－12 Ta	STA; 〃 → 〃
	12	Ti－24 Nb－14 Ta	STA; 〃 → 〃
	13	Ti－30 Nb－15 Ta	STA; 〃 → 500℃×3 hr
	14	Ti－37 Nb－10 Ta	STA; 〃 → 450℃×3 hr
	15	Ti－42 Nb－ 8 Ta	STA; 〃 → 〃
	16	Ti－18 Nb－10 Ta－2 Mo	ST ; 844℃×0.5 hr
	17	Ti－18 Nb－10 Ta－2 Mo	STA; 〃 → 400℃×3 hr
	18	Ti－16 Nb－13 Ta－4 Mo	ST ; 844℃×0.5 hr
	19	Ti－16 Nb－13 Ta－4 Mo	STA; 〃 → 450℃×3 hr
	20	Ti－34 Nb－20 Ta－4.6 Zr	ST ; 844℃×0.5 hr
	21	Ti－34 Nb－20 Ta－4.6 Zr	STA; 〃 → 400℃×3 hr
	22	Ti－29 Nb－13 Ta－4.6 Zr	ST ; 844℃×0.5 hr
	23	Ti－29 Nb－13 Ta－4.6 Zr	STA; 〃 → 450℃×3 hr
	24	Ti－29 Nb－13 Ta－4.6 Sn	ST ; 844℃×0.5 hr
	25	Ti－29 Nb－13 Ta－4.6 Sn	STA; 〃 → 400℃×3 hr
	26	Ti－29 Nb－13 Ta－2 Sn	ST ; 844℃×0.5 hr
	27	Ti－29 Nb－13 Ta－2 Sn	STA; 〃 → 400℃×3 hr
比較例	1	Ti－6 Al－4 V	ST ; 955℃× 1 hr
	2	Ti－6 Al－4 V	STA; 〃℃× 1 hr→480 ℃×4 hr
	3	Ti－5 Al－2.5 Fe	ST ; 〃℃× 1 hr
	4	Ti－5 Al－2.5 Fe	STA; 〃℃× 1 hr→520 ℃×4 hr
	5	Ti－13 Nb－13 Zr	ST ; 775℃× 1 hr
	6	Ti－13 Nb－13 Zr	STA; 〃℃× 1 hr→425 ℃×4 hr

[Table 2]

	No	引張り強さ(σ_B/MPa)	0.2%耐力($\sigma_{0.2}$/MPa)	伸び率 (%)	弾性率 (GPa)
実施例	1	863	840	3	115
	2	803	715	5	73
	3	1210	1190	3	115
	4	560	205	31	63
	5	570	270	36	65
	6	580	410	19	55
	7	560	380	21	53
	8	566	373	23	53
	9	420	415	27	50
	10	840	827	4	104
	11	1185	1147	4	112
	12	1030	968	3	78
	13	430	425	20	53
	14	580	410	17	61
	15	570	410	23	50
	16	776	564	22	80
	17	989	852	15	81
	18	634	550	66	46
	19	1200	1170	3	112
	20	415	410	31	49
	21	419	417	25	50
	22	522	245	42	50
	23	574	330	18	56
	24	527	453	27	60
	25	1035	975	3	65
	26	562	397	23	60
	27	1021	1000	5	67
比較例	1	896	827	15	114
	2	953	822	10	114
	3	901	843	15	115
	4	943	886	11	115
	5	798	599	20	83
	6	994	864	18	81

[Translation done.]